EFFECT OF TIME AND TEMPERATURE ON CHRACTERISTICS AUSTEMPERING (20X1MΦA) LOW ALLOY STEEL

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Abstract

We examined in this study, the effect of austempering time and temperatures on microstructure and mechanical properties of (20X1MΦA) low alloy steel steel, which is commonly used in producing pipeline of oil, was investigated. (20X1MΦA) low alloy steel specimens were austenitized at 890°C for 30 min and then were quenched into a salt bath held at two different austempering temperatures (400°C, 600°C) and austempered for various times (20 sec, 60 sec, 180 sec and 540 sec). Microstructure constituents were characterized by using optical microscope. Impact toughness and hardness tests were conducted to determine the mechanical properties of (20X1MΦA) low alloy steel. Experimental results showed that, enhancement of the impact toughness of this kind of steel depend on the bainitic structure. The selection of austempering temperature constitutes a key parameter to obtain superior impact toughness − hardness combination in (20X1MΦA) low alloy steel used in pipeline of oil and high pressure tank.

Introduction

Selection of the optimal treatment temperature and time calls for study of austenite-grain growth on heat treating and disintegration kinetics of the supper cooled austenite. In addition, account must be taken of the influence of the decomposition products of austenite by various mechanisms, on the steel properties. Low alloy chromium-molybdenum-vanadium steel containing 0.2-0.35% C used for production oil and gas pipelines requires high-strength and corrosion resistance. (20X1MΦA) while relatively inexpensive provides an acceptable combination of strength and plasticity. Transformation, or "austempering," of a carbon-containing austenite at elevated temperatures yields so-called "intermediate products." Their structure and properties are, for a given hardness, rather different from those of "tempered martensite" obtained on conventional quenching and tempering [1]. Several investigators [2,3] have found that for high carbon and slightly alloyed steels the intermediate products formed at temperatures close to that of the martensite reaction possess strength properties superior to those of tempered martensite. The structure of these low temperature, intermediate products is generally acicular (bainite) but clearly different from that of martensite. However, at higher austempering temperatures, between and (400^0 and 600°C) carbon steels were found to exhibit a rather low ductility [4,5]. Thus notch bar tensile tests showed the ratio between notch strength and regular tensile strength to decrease with increasing austempering temperature. For ductilities below a few percent this notch strength ratio is a measure of ductility, according to investigations on low alloy steels [6,7]. Furthermore the presence of intermediate products formed unintentionally on quenching was considered as responsible for the low ductility and impact energy of some heat treated steels [8]. These intermediate products could result from partial transformation at the so-called "nose-temperature" where the rate of the transformation is a maximum. Tempering improved such mixtures of martensite and intermediate products, their properties approaching those of tempered martensite of equal hardness. The following investigation constitutes an attempt to determine certain strength properties of a partially austempered and subsequently quenched low alloy steel, namely, a chromium-molybdenum-vanadium steel (20X1MΦA). The structures formed by such a treatment should consist of a mixture of intermediate products formed on austempering and a martensite formed on oil quenching from the austempering temperature. It was intended, by varying the austempering time, to vary the quantity of the intermediate products between zero and 100 pct. The austempering temperature of 400^{0}C was selected after extensive preliminary tests close to the nose-temperature. Austempering at this temperature yielded an acicular intermediate product. Additional tests under less exacting conditions were made for an austempering temperature of 600°C where the intermediate product appeared to be very fine bianite.

Experimental Details

Specimens (10x10x60) mm of (20X1MΦA) low alloy steel were having a nominal composition as shown in Table1.

Table 1.Chemical composition of (20X1MΦA) of low alloy steel

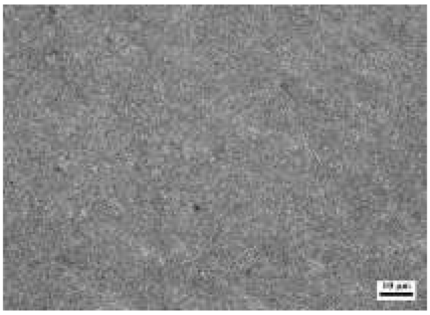
C	Cr	Mo	V	Mn	Si	Ni	Ca	Al	N_2	P	S
0.2	1.3	0.41	0.081	0.58	0.25	0.1	0.0026	0.026	0.162	0.008	0.003

The initial microstructure of specimens have fully martensite as annealed condition. Specimen were austenitized at 890°C for 30 min followed by instantaneous transfer to a salt bath for austempering at 400°C, 600°C , for different time periods ranging from 20 to 540 sec. Following austempering, specimens were water quenched to room temperature. The heat treated specimens were cut and hot mounted for mechanical grinding and polishing with up to 1 μm diamond suspension and etching with 2 % Nital. Microstructure features were studied using Nikon Epiphot200 optical microscope. Phase volume fractions were calculated by image analyzer software of Nikon NIS-Elements. Charpy impact tests were conducted at room temperature with a impact testing machine on unnotched specimens with dimension of 10 mm × 10 mm × 60mm. Hardness measurements were made using hardness tester. At least five indents were made at each location and average values were taken.

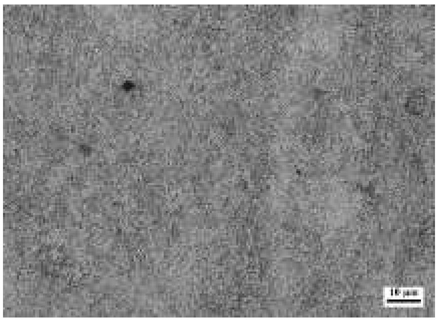
Experimental Results and Discussion

1. Microstructure and hardness examination

For specimens were inspection (20X1MΦA) low alloy steel microstructures has basically bianite but in the fact we has some percentage of martensite and carbides as shown in fig. 1.



a



b

Fig.1 Bainite by austempering a)400^{o}C, b) 600^{o}C

2. Effects of austempering temperatures

Table 2 and 3 shows the impact energy variations and changes in the hardness values with austempering temperature in (20X1MΦA) steels austempered for different times, respectively. According to tables, increasing the austempering temperature improves the impact toughness for all austempering times. It is clear that the impact toughness values of the specimens which were austempered at 400°C was lower than those of austempered at 600°C. It can be explained the volume fractions of bainite and martensite. At constant austempering time the higher austempering temperatures produces more bainite volume fraction in austempered (20X1MΦA) (see Fig. 1.a, b). Moreover, impact toughness properties are expected to be further improved due to the upper bainitic microstructure in austempered (20X1MΦA) low alloy steel. Experimental results indicate that the volume fraction and of bainite and martensite is important parameters affecting the impact toughness and the hardness. In addition, higher amount of bainite is essential in order to improve impact toughness. Moreover, it has been shown that controlling the bainite, martensite and the retained austenite volume fractions can further influence impact toughness of austempered (20X1MΦA) steels. The austempering temperatures more effective than austempering time to control of the bainite volume fraction in (20X1MΦA) low alloy steel. The hardness decreased with increasing austempering temperatures (see table 2). It can be attributed to higher bainite volume fraction at high austempering temperatures.

3. Effects of austempering times

The impact energy variations with austempering time in (20X1MΦA) steel austempered at each two austempering temperature. After 20 sec., the impact toughness remained almost unchanged at 600°C due to nearly completion of bainitic reaction. But however, the impact toughness values increased with increasing austempering time for specimen's austempered at 400°C. It is apparent that the bainite volume per cent increases, while both the austenite and martensite volume fraction decreases with increasing austempering time. Experimental results showed that the austempering time has great influence on the impact toughness of (20X1MΦA) low alloy steel. There is a good agreement in existing literature

Table.2 Mechanical properties of (20X1MΦA) obtained by 400^0C and 600^0C salt furnace

$400^oC/600^oC$	20 sec	60 sec	180 sec	540sec
$\sigma_{0,2}$, МПа	759/838	755/832	787/817	802/817
$\sigma_в$, МПа	1106/1121	1102/1171	1080/1157	1110/1139
δ_p%	9/7	8,5/9	9/9	10,5/8,5
δ%	28/27	27/27	28/27	29,5/27
KCV,J	51/80	52/88	80/85	75/84
HRC	38/35	37/29	41/38	41/36

4. Conclusion

The following conclusions could be drawn from this study:

• Bainite + martensite duplex microstructures can be produced in (20X1MΦA) low alloy steel via combination of austempering and quenching processes.

• Bainite + martensite obtaind by 400^0C duplex microstructure yields in high levels of hardness (36-42 HRC) and enhanced impact toughness (45-80 Joule).

• Austempering temperatures are more effective than austempering time to control the bainite volume fraction in (20X1MΦA) low alloy steel.

Acknowledgement

The authors wish to acknowledge the financial supports Ural federal University Named after First President of Russia B.N.Yeltsin.

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